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## PATENT SPECIFICATION

732,710

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Index at Acceptance :—Class 39(3), H1X, H2E4(B : H).

### COMPLETE SPECIFICATION.

#### Improvements in or relating to Electric Heating Elements.

We, N. GREENING & SONS LIMITED, a British Company, of Britannia Works, Warrington, in the County of Lancaster, do hereby declare the invention, for which we  
5 pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement :—

This invention is for improvements in or relating to electric heating elements and particularly what are known as surface heating elements or panels.

It is known to use thin electro-formed sheets of nickel or other metals for the heating of particular areas by the passage of an electric current through such sheets. In order to obtain the necessary characteristics of electrical resistance it has heretofore been necessary to use very thin flimsy strips or sheets of metal. These are cut in a complex zig-zag pattern so as to increase the length of the conducting path for the electric current. Such flimsy strips or sheets are very susceptible to mechanical damage which may  
25 either break the conducting path completely or reduce the cross-section at the point of damage to such an extent as to raise the resistance by a substantial amount. As a consequence of this increase in resistance there is an objectionable temperature rise followed again by a further rise in resistance and an increase in temperature and so on until the temperature has risen to such an extent as to cause complete failure at the point of damage. Furthermore with these flimsy metal sheets or strips, which may have a thickness of the order of 1,000th of an inch or less, there is great difficulty in making satisfactory electrical connections.

An object of the present invention is to provide metal surface heating elements which do not suffer from the defects just set forth.

According to the present invention there is

provided an electric heating element in the form of a conducting plate, sheet or strip 45 formed by a process of electro-deposition so as to have a multiplicity of very small perforations arranged to provide a plurality of tortuous paths in parallel for the flow of current from one part of the plate, sheet or strip to another so that should any one path be damaged or destroyed the current may flow round the fault without undue rise of temperature.

Conveniently the conducting plate, sheet or strip is perforated with small apertures or slots (e.g. of the order of 0.2" x 0.015" or less) and notched or gapped alternately from opposite sides of the plate, sheet or strip at intervals so as to constrain an electric current to flow from one part of the sheet, plate or strip to another along a tortuous path made up of a plurality of smaller paths in parallel.

The plate, sheet or strip may be provided with unperforated edges or areas for the attachment to it (e.g. by soldering) of electrical conductors for connecting the element in a supply circuit.

The perforated metal sheet for the purpose of the present invention may be made by a known process of electro-deposition the slot or hole pattern being formed during this process of manufacture. Material of this nature is available commercially in which the holes or slots are of extremely small or minute dimensions. The slots or holes forming the perforations in the sheet need not necessarily for the purpose of the invention be very minute but it is contemplated that they will at least be relatively small. For instance, where the perforations are in the form of slots there may be between one hundred and one thousand such slots to the square inch of material.

The invention will be further described by way of example with reference to the

diagrammatic drawing accompanying our Provisional Specification whereon:—

Figure 1 shows one embodiment of a surface heating element according to the invention; and

Figure 2 is an enlarged view of a small area of the heating element shown in Figure 1.

The heating element shown in Figure 1 is made from perforated electro-deposited metal (e.g. nickel) sheet the perforations being of elongated form and those in one row being staggered with respect to those in neighbouring rows as shown in Figure 2. It is convenient to make the bridges 10 lying between the ends of neighbouring slots approximately 2 to 2½ times as wide as the bridges 11 lying between the sides of neighbouring slots. This helps to ensure that the current density at any section of the sheet is approximately the same.

The perforated sheet material is cut or slotted (as indicated at 12 in Figure 1) alternately from opposite sides. This results in the formation of tortuous paths for the flow of current from, for example, a conductor 13 connected to one pole of the supply to conductors 14 connected to the other pole. It will be appreciated that these tortuous paths are themselves made up of a plurality of tortuous paths in parallel formed by the staggered perforations in the sheet as indicated in Figure 2. The general direction of flow of current is indicated by arrows in both Figures 1 and 2 and it will be seen that the path along which the current has to flow is relatively long compared with the overall dimensions of the sheet. The number of paths in parallel will of course depend on the number of perforations.

It will be appreciated that by perforating the sheet forming the heating element its resistance is very materially increased so that its thickness can be increased whilst still maintaining an element having a resistance and heating capacity comparable with much thinner or flimsy sheets as available heretofore. This increased thickness of the sheet greatly facilitates the making of electrical connections thereto e.g. by soldering. Preferably these electrical connections are made to the unperforated areas or edges 15 provided along opposite sides of the sheet as indicated in Figure 1. It will be noted that the slots 12 extend right up to and into the unperforated areas. Not only do the unperforated areas facilitate the making of electrical connections but they also serve as low resistance paths giving an even distribution of current along the various parallel paths traversing the narrow strips from one solid margin 15 to the other.

It will be understood that the dimensions or gauge of the slot mesh (as shown in Figure 2) together with the distance between the cuts 12 determines the number of paths (made up

of the bridges 10 and 11) in parallel. It is contemplated that a suitable minimum number of parallel paths for most cases will be 10 although as few as 5 may be used for special cases. Increasing the number of equally spaced cuts 12 between two points in the length of the strip will increase the resistance of the path for the electric current approximately as the square of the total since each cut decreases the number of current paths in parallel and also at the same time increases the total length of the path.

One particular application of the invention is to de-icing equipment for aircraft wings, the heating elements, in this case, being provided with means for their attachment to said wings.

What we claim is:—

1. An electric heating element in the form of a conducting plate, sheet or strip formed by a process of electro-deposition so as to have a multiplicity of very small perforations arranged to provide a plurality of tortuous paths in parallel for the flow of current from one part of the plate, sheet or strip to another so that should any one path be damaged or destroyed the current may flow round the fault without undue rise of temperature.

2. An electric heating element as claimed in Claim 1 and wherein the conducting plate, sheet or strip is notched or gapped alternately from opposite sides at intervals so as to constrain electric current to flow from one part of the sheet, plate or strip to another part along a tortuous path made up of a plurality of smaller tortuous paths in parallel.

3. An electric heating element as claimed in Claim 1 or Claim 2 wherein the perforations are arranged in staggered relationship.

4. A heating element as claimed in any of the preceding claims wherein the perforations are of elongated form and extend in the direction of length of the plate, sheet or strip.

5. A heating element as claimed in any of the preceding claims wherein the perforations have dimensions of the order of 0.2" x 0.015" or less.

6. A heating element as claimed in any of Claims 2, 3, 4 or 5 wherein the notches or gaps extending alternately from opposite sides of the plate, sheet or strip are at short spaced intervals.

7. A heating element as claimed in any of the preceding claims wherein the plate, sheet or strip has unperforated edges or areas for the attachment to it of electrical conductors for connecting it in an electricity supply system.

8. A heating element as claimed in any of the preceding claims wherein there are between 100 and 1000 perforations to the square inch of plate, sheet or strip.

9. A heating element as claimed in any of the preceding claims wherein the spacing

between the ends of neighbouring perforations is approximately two to two-and-a-half times as great as the spacing between the sides of neighbouring perforations.

- 5 10. An electric heating element substantially as herein described with reference to the accompanying drawing.

11. A de-icing means for aircraft wings

comprising a heating element as claimed in any of the preceding claims.

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Dated this 19th day of February, 1954.

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Water Street, Liverpool, 3.

### PROVISIONAL SPECIFICATION.

#### Improvements in or relating to Electric Heating Elements.

We, N. GREENING & SONS LIMITED, a British Company, of Britannia Works, Warrington, in the County of Lancaster, do hereby declare this invention to be described in the following statement :—

This invention is for improvements in or relating to electric heating elements and particularly what are known as surface heating elements or panels.

20 It is known to use thin electro-formed sheets of nickel or other metals for the heating of particular areas by the passage of an electric current through such sheets. In order to obtain the necessary characteristics of electrical resistance it has heretofore been necessary to use very thin flimsy strips or sheets of metal. These are cut in a complex zig-zag pattern so as to increase the length of the conducting path for the electric current. Such flimsy strips or sheets are very susceptible to mechanical damage which may either break the conducting path completely or reduce the cross-section at the point of damage to such an extent as to raise the resistance by a substantial amount. As a consequence of this increase in resistance there is an objectionable temperature rise followed again by a further rise in resistance and an increase in temperature and so on until the temperature has risen to such an extent as to cause complete failure at the point of damage. Furthermore with these flimsy metal sheets or strips, which may have a thickness of the order of 1,000th of an inch or less, there is great difficulty in making satisfactory electrical connections.

An object of the present invention is to provide metal surface heating elements which do not suffer from the defects just set forth.

50 According to the present invention there is provided an electric heating element in the form of a conducting plate, sheet or strip which is perforated so as to provide a plurality of tortuous paths in parallel for the flow of current from one part of the plate, sheet or strip to another, so that should any one path be damaged or destroyed the current may flow round the fault without undue rise of temperature.

60 According to a further feature of the

present invention there is provided an electric heating element in the form of a conducting plate, sheet or strip perforated with small apertures or slots (e.g. of the order of 0.2" x 0.015" or less) and notched or gapped alternately from opposite sides of the plate, sheet or strip at intervals so as to constrain an electric current to flow from one part of the sheet, plate or strip to another along a tortuous path made up of a plurality of smaller paths in parallel.

According to a still further feature of the present invention there is provided an electric heating element in the form of a conducting plate, sheet or strip perforated with small apertures or slots (e.g. of the order of 0.2" x 0.015" or less) arranged in staggered relationship, the plate, sheet or strip being notched or gapped alternately from opposite sides or edges at intervals, whereby an electric current is constrained to flow from one part of the plate, sheet or strip to another along a tortuous path itself made up of a plurality of smaller tortuous paths in parallel.

Conveniently the plate, sheet or strip is provided with unperforated edges or areas for the attachment to it (e.g. by soldering) of electrical conductors for connecting the element in a supply circuit.

It is contemplated that the perforated metal sheet for the purpose of the present invention will be made by a process of electro-deposition the slot or hole pattern being formed during this process of manufacture. Material of this nature is available commercially in which the holes or slots are of extremely small or minute dimensions. The slots or holes forming the perforations in the sheet need not necessarily for the purpose of the invention be very minute but it is contemplated that they will at least be relatively small. For instance, where the perforations are in the form of slots there may be between one hundred and one thousand such slots to the square inch of material.

The invention will be further described by way of example with reference to the accompanying diagrammatic drawing whereon :—

Figure 1 shows one embodiment of a

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surface heating element according to the invention; and

Figure 2 is an enlarged view of a small area of the heating element shown in Figure 1.

5 The heating element shown in Figure 1 is made from perforated electro-deposited metal (e.g. nickel) sheet the perforations being of elongated form and those in one row being staggered with respect to those in neighbouring rows as shown in Figure 2. It is convenient to make the bridges 10 lying between the ends of neighbouring slots approximately 2 to 2½ times as wide as the bridges 11 lying between the sides of neighbouring slots.

10 This helps to ensure that the current density at any section of the sheet is approximately the same.

The perforated sheet material is cut or slotted (as indicated at 12 in Figure 1) alternately from opposite sides. This results in the formation of tortuous paths for the flow of current from, for example, a conductor 13 connected to one pole of the supply to conductors 14 connected to the other pole.

20 It will be appreciated that these tortuous paths are themselves made up of a plurality of tortuous paths in parallel formed by the staggered perforations in the sheet as indicated in Figure 2. The general direction of flow of current is indicated by arrows in both Figures 1 and 2 and it will be seen that the path along which the current has to flow is relatively long compared with the overall dimensions of the sheet. The number of paths in parallel will of course depend on the number of perforations.

It will be appreciated that by perforating the sheet forming the heating element its resistance is very materially increased so that its thickness can be increased whilst

still maintaining an element having a resistance and heating capacity comparable with much thinner or flimsy sheets as available heretofore. This increased thickness of the sheet greatly facilitates the making of electrical connections thereto e.g. by soldering. Preferably these electrical connections are made to the unperforated areas or edges 15 provided along opposite sides of the sheet as indicated in Figure 1. It will be noted that the slots 12 extend right up to and into the unperforated areas. Not only do the unperforated areas facilitate the making of electrical connections but they also serve as low resistance paths giving an even distribution of current along the various parallel paths traversing the narrow strips from one solid margin 15 to the other.

It will be understood that the dimensions or gauge of the slot mesh (as shown in Figure 2) together with the distance between the cuts 12 determines the number of paths (made up of the bridges 10 and 11) in parallel. It is contemplated that a suitable minimum number of parallel paths for most cases will be 10 although as few as 5 may be used for special cases. Increasing the number of equally spaced cuts 12 between two points in the length of the strip will increase the resistance of the path for the electric current approximately as the square of the total since each cut decreases the number of current paths in parallel and also at the same time increases the total length of the path.

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FIG. 1

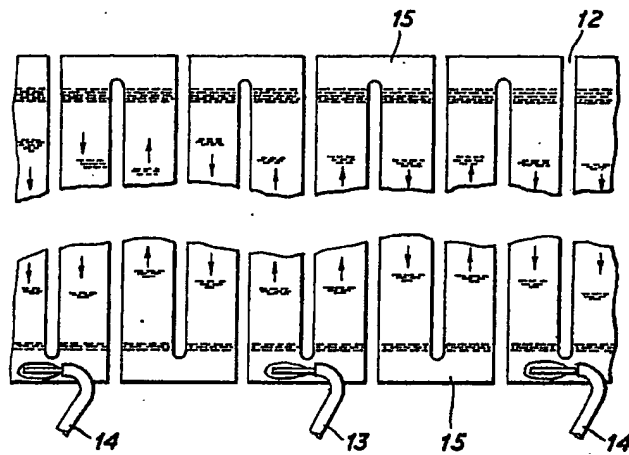


FIG. 2

